The Army Science Board

Fiscal Year 2023 Study

An Independent Assessment of the Army Implementation of Digital Engineering (DE)

Annotated Briefing

August 2023

Department of the Army
Office of the Assistant Secretary of the Army
(Acquisitions, Logistics and Technology)
Washington, DC 20310-0103

The Army Science Board (ASB), organized under the Federal Advisory Committee Act (FACA) in 1977, provides the Army with independent advice and recommendations on matters relating to the Army's scientific, technological, manufacturing, acquisition, logistics and business management functions, as well as other matters the Secretary of the Army deems important to the Department of the Army.

The ASB's members and consultants are eminent authorities in the disciplines of science, technology, engineering, math, social science, business, and governance. The Board also draws upon the expertise of senior retired military officers from all branches of service. All are dedicated experts who volunteer their time to provide independent assessments to Army senior civilian and military leadership.

The following report is a product of the ASB. The statements, opinions, conclusions, and observations contained in this report are those of the ASB study members and do not necessarily reflect the official position of the United States Army or the Department of Defense.

This document is available in electronic format from the Defense Technical Information Center (DTIC) at http://www.dtic.mil.

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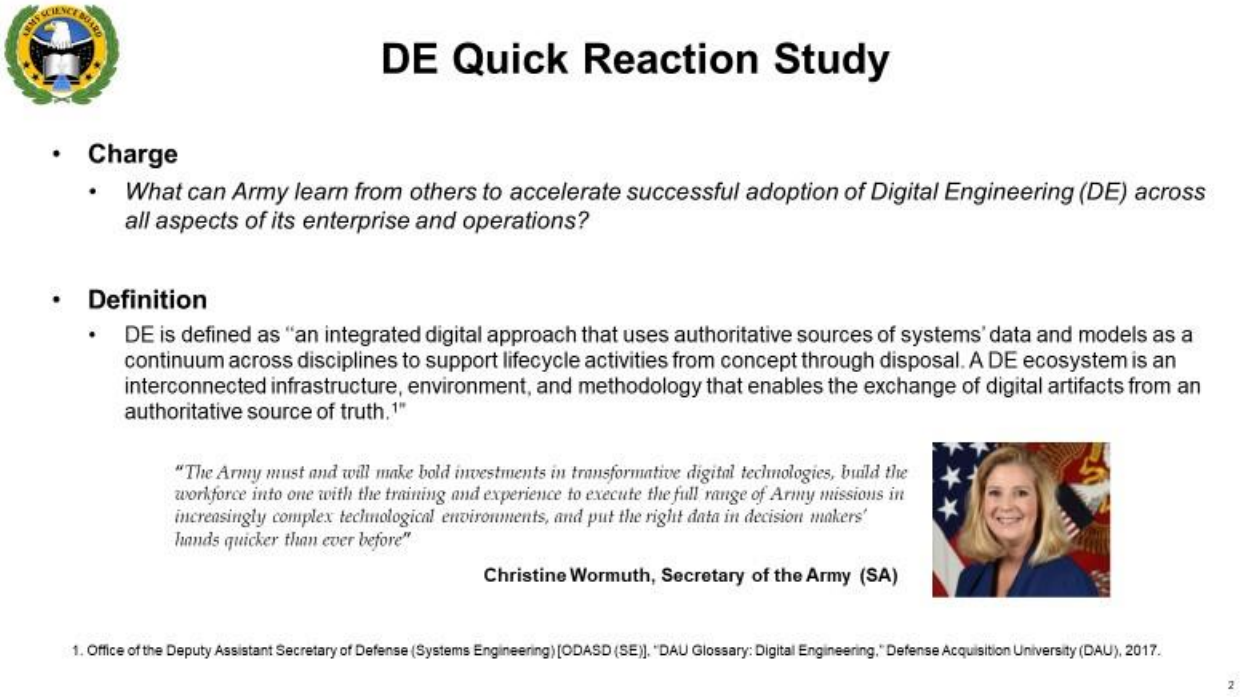
BACKGROUND

The Army is committed to implementing the necessary transformations to ensure data gets to decision makers as quickly as possible. This briefing summarizes the findings and recommendations of the Army Science Board (ASB) regarding what the Army could learn from others and apply to accelerate the successful adoption of digital engineering (DE) across its enterprise and operations. The emphasis of the study was on learning from industry. To successfully complete the study and maximize its utility, the study team first sought to settle on a definition of DE.



The study team observed that DE means different things to different people, and there is no standard set of definitions. To baseline the study, the study team adopted the DoD definition of DE—an "integrated digital approach using authoritative sources of system data and models as a continuum across disciplines to support life cycle activities from concept through disposal."[1] Thus, DE exists within an ecosystem made up of an interconnected infrastructure, environment, and methodology that allows the exchange of digital artifacts from authoritative sources of truth, so that all stakeholders and users within the ecosystem are working off the same concepts. The study team considered DE artifacts to be the various products, documents, models, software, etc., produced by elements of the DE ecosystem.

[1] Office of the Deputy Director for Engineering; Office of the Under Secretary of Defense for Research and Engineering. Systems Engineering Guidebook. Washington, D.C.; February 2022. 20.

Framing Assumptions

- **This is an accelerated limited-scope study responding to the Under Secretary of the Army's (USA's) request to inform Army's near-term investment strategies and interactions with industry**
  - Quick Reaction Team (QRT) tasked 19 April 2023 to deliver an annotated briefing to Army Science Board mid-July 2023
- **Army wants to take action to accelerate DE in the Near Term (Fiscal Years (FY) 2024-2025)**
  - Army's current activities and DE maturity supports this goal
- **Army understands DE is a long-term journey and that benefits of DE accrue over time as more non-materiel functions are added**
- **This study focuses on big "A" acquisition and more specifically materiel development where incremental steps can be taken now and show results within 18 months**
- **Army will seek to estimate and appropriate funding to make new and continuing investments, including policies, processes, and people to realize long-term benefits throughout the DE lifecycle**

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The Undersecretary of the Army (USA), the study's sponsor, requested the ASB accelerate the conduct of the study to better align with Army budget planning and near-term investment timelines. As a result, a smaller study team was formed to address a narrower scope of the Terms of Reference (see Appendix A). Specifically, the USA sought to have the study inform the Army's engagements with industry and other organizations, and to help to shape the Army's near-term (FY24-25) investments. The study team assumed senior Army leaders wanted to move quickly, capitalizing on the maturity of DE and the ongoing efforts within the Army to further its implementation.

Based on the work that was already underway, the study team also assumed that the Army understood that DE was not a "one-and-done" activity but rather a long-term journey, and that the benefits of DE would compound as increased capabilities, material, and non-material functions were added. The more users and capabilities employed DE, the more valuable it would become to the organization and to the Army enterprise (network effect).

In keeping with the concentration on near-term implementation, the study team focused on materiel development where the Army could take immediate, incremental steps over the next 18 months to demonstrate results. The incremental approach would provide a DE value proposition past FY24-25, allowing the Army to determine future costs and to make the appropriate investments for new and continuing activities. These include updating policies, processes, and investing in people to maximize benefits across the DE lifecycle.

Framing Assumptions - Concluded

- **It is infeasible in the FY2024 and FY2025 timeframe to form a new office reporting to the SA, USA, and/or Chief of Staff of the Army (CSA)**
  - Cannot be implemented in time to effect results in that time frame
  - Current Army efforts have been planned and are being executed in local communities without significant central control
  - Army Staff (ARSTAF) and Secretariat roles have been supportive to the individual efforts
- **Lessons learned from industry are relevant to the Army**
  - Industry invests in DE and has metrics to improve their bottom line
  - Therefore, the Army needs to invest in DE and metrics to improve its outcomes
- **Deputy Assistant Secretary for the Army (Data, Engineering & Software) DASA(DES) is looking at tools and standards; thus the QRT did not**
- **Estimating implementation costs was outside of the scope of this QRT**
- **The Intelligence Community (IC) will evolve a threat model that supports Army's adoption of DE to enable successful acquisition**

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Given the near-term focus, the study team assumed it would be infeasible to form a new office or organization reporting to the Secretary of the Army, the USA, and/or the Chief of Staff (CSA) or Vice Chief of Staff of the Army (VCSA). Ongoing DE efforts across the Army have been executed through bold and independent initiatives without significant central control, and senior Army leaders have been supportive of those individual activities. That said, the study team acknowledges that over time, the Army would benefit from some centralized control.

The study team assumed industry efforts in DE are relevant to the Army. While industry's constraints and motivations differ, there is much to be learned from what they are doing that would benefit the Army. Industry does invest in DE. The study team notes that industry is investing in DE to enhance its bottom line and is measuring progress accordingly. Industry has metrics to show the value of DE. In parallel, the Army should consider its bottom line, which is readiness, and align the investment in DE along with appropriate metrics to measure progress towards the Army's outcome. *How is the Army going to improve readiness with DE?*

Since the Deputy Assistant Secretary for the Army for Data Engineering and Software, DAS(DES) is already looking at the Army's tools and standards, the study team did not look at those. The study team determined there was no need to duplicate that effort. Additionally, the study team assumed that estimating DE costs would be a follow-on activity and out of scope for this study. The final framing assumption made by the study team was that because the Army is planning against a threat-based environment, the Army's acquisition model must be threat-based as well. It is necessary but insufficient for the acquisition community to focus on DE. The Intelligence Community (IC) must be a close partner. The Army must consider the overall ecosystem and

ensure the IC is bringing in DE processes and products to inform, drive, and support those acquisitions while also helping protect and defend the artifacts within that ecosystem.

Methodology

- **Study team performed open-ended structured interviews along lines of inquiry with a sampling of 21 DE leaders across the community of interest**
  - Industry (8), Army (6), Other Department of Defense (DoD) (4), National Nuclear Security Agency (NNSA) (1), Associations (1), Federally Funded Research and Development Centers (FFRDCs) (2)
  - Interview method did not lend itself to a statistical analysis
- **Examined hundreds of DE reports and presentations to identify lessons learned/best practices to benefit Army's adoption of DE**
- **Interviews and reviews formed the basis of our study recommendations**

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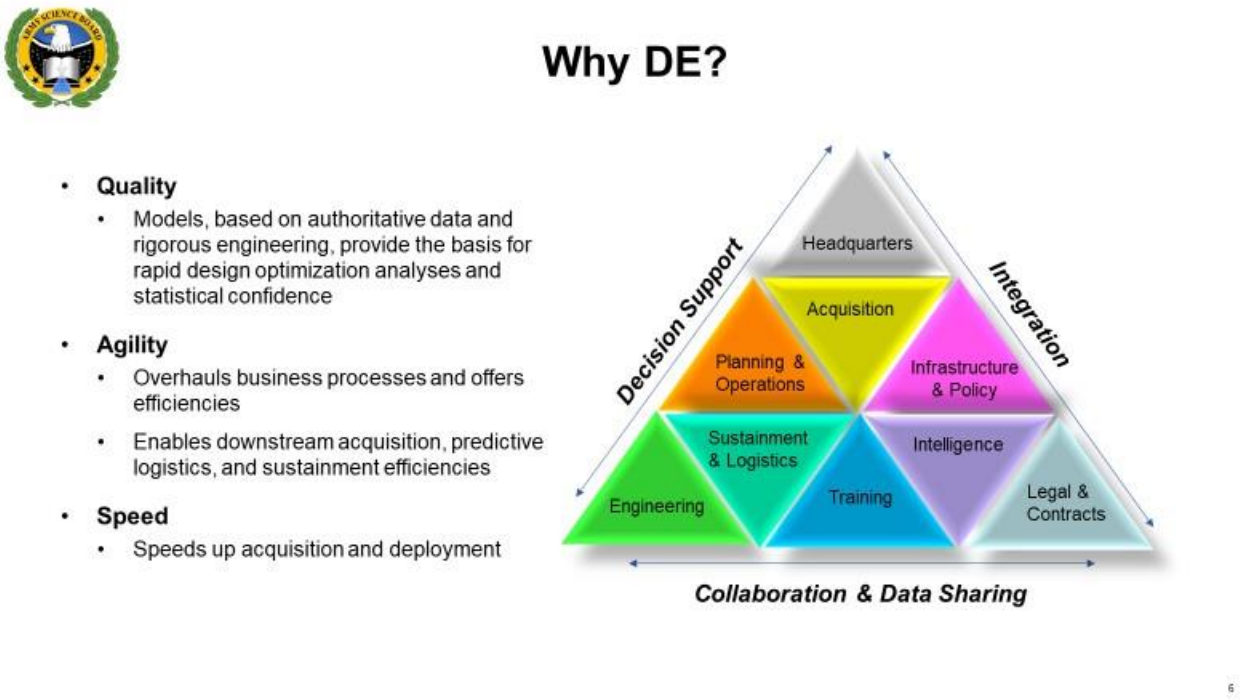
Overall, the study team's methodology was designed to quickly gather comprehensive information from a diverse range of sources in order to develop informed recommendations for the Army's DE initiatives. By examining best practices and lessons learned from industry leaders, the study team aimed to provide practical guidance that could help the Army achieve its near-term DE goals.

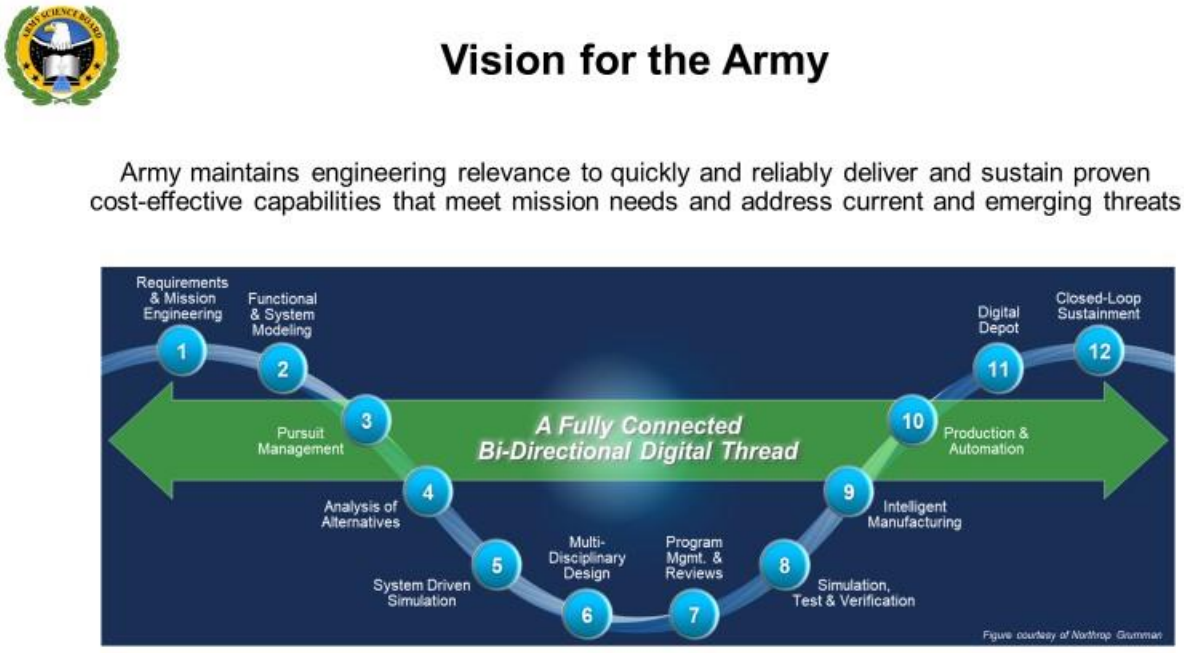
Because the study team had limited time, it established a structure with a series of lines of inquiry to guide the study. The study team conducted a sampling of structured interviews of 21 DE leaders across the community of interest. That community of interest spanned eight companies, six Army organizations, and a number of other DoD organizations including Navy, Air Force, and Space Force. The study team reached out to the Department of Energy National Nuclear Security Agency, associations like the International Council on Systems Engineering (INCOSE), and two FFRDCs (The MITRE Corporation and The Aerospace Corporation). Because the study team's approach relied on open ended questions, it did not lend itself to statistical analysis. However, the study team discovered that themes in the interview responses converged in many cases and were able to derive recommendations from that. The study team also noted there were hundreds of reports, studies, and presentations that have been conducted on DE and many of these are recent and funded by the DoD. The study team reviewed hundreds of reports and presentations to identify lessons learned and best practices that could apply to the Army. The study team developed a high degree of confidence that this process was sufficient and in fact did inform findings and formed the basis of the study recommendations.



Through the study team's research, three key motivators for DE emerged. The first was a significant improvement in quality by leveraging common models across the enterprise built on a foundation of approved, authoritative data combined with rigorous engineering. Rigorous engineering was consistently seen as critical to successful DE and something that cannot be outsourced. Combining engineering and models allows for rapid design optimization. This enables organizations to answer questions, analyze, conduct statistical competence improvements end-to-end, and realize quality improvements. Additionally, organizations could increase the speed of decision-making with DE by paying attention to business processes in addition to engineering components. DE may also enable much faster and smarter downstream decisions when it comes to logistics, sustainment activities and the ability to do predictive analysis and reaping those efficiencies. Finally, DE increases the speed of end-to-end acquisition and deployment.

The diagram illustrates how individual organizations can be seen as part of an end-to-end, full life cycle, system engineering complex effecting decision support and integration through collaboration and data sharing. DE provides its real value and bang for the buck across the enterprise when it enables decision support, integration, collaboration, and data sharing across all elements of the enterprise all the way up to headquarters, working across the entire community of organizations and stakeholders. The goal is integrating and collaborating across engineering, sustainment and logistics, staffing, training, intelligence gathering, security and protection, legal, contracts, infrastructure, and policy to enable information exchange and acquisition activities to support operations in the field. All the information being shared across those aspects can act as a force multiplier to improve readiness significantly.

An important observation made by the study team is that cost should not be the main driver for the Army's adoption of DE. DE will not solve all of the Army's problems and it will inevitably introduce new problems. The incentive to adopt DE is that by combining it with rigorous engineering and authoritative sources of data and models the Army can achieve rapid design optimization, test for safety, and assess proposed capabilities. Industry shared multiple examples of impressive and effective applications of DE. The focus is on quality, agility, speed, and not on cost. Army should not expect immediate saving from DE. Because the Army is behind, DE may shift the profile of Army's spending. Army should be realistic about that.

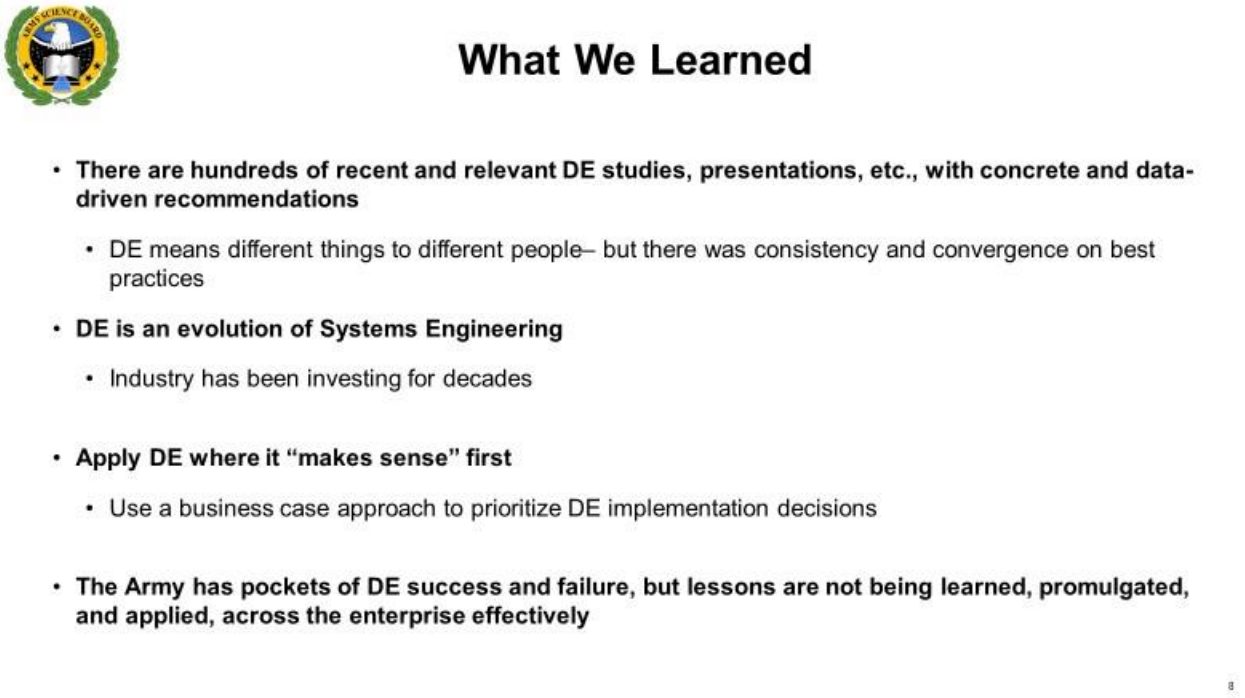


This slide presents a vision for the Army's engagement with DE, emphasizing its crucial role in maintaining engineering relevance. The goal will be to rapidly and dependably provide and sustain proven, cost-effective capabilities. These should address mission needs and counter both existing and emerging threats. Quality is improved by using authoritative and trustworthy models, which can assess cases with greater statistical confidence than could otherwise be obtained because of cost, availability, and other constraints.

The study team used a figure provided by the Northrop Grumman Corporation, to illustrate that Army can develop a fully connected, bidirectional, digital thread from concept to sustainment. Within this process, requirements are refined to address mission needs, while also ensuring affordability. Design engineering models are used to validate efficient product assembly and plant layout, increase statistical confidence through the use of digital models in test and evaluation, and enable predictive maintenance and efficient repair operations for maintainers and sustainers. DE could work across all of this, link it through and enable both planning and

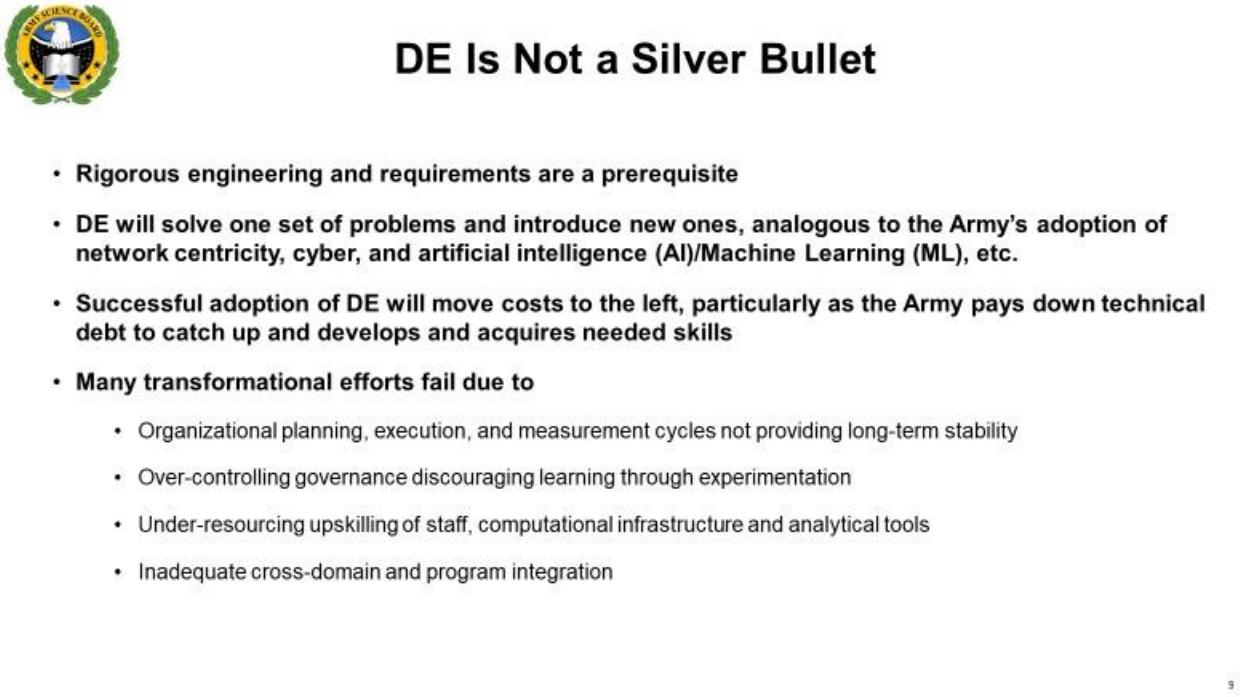
management as well as the production and automation. By leveraging this vertically as well across all aspects of the enterprise and implementing it appropriately, the Army could realize a real force multiplier when it comes to capability. By leveraging digital technologies and processes throughout the acquisition lifecycle the Army will be more agile, effective, and better equipped to face the challenges of the future.

DE is no longer a unique competitive advantage but has become the standard way of conducting business in industry. Industry leaders, despite challenges in application and adoption, are committed to this digital transition. The urgency for the Army is underscored in terms of keeping pace with the industry's evolution, rather than lagging behind and adhering to standards already established by the larger community. The diagram emphasizes that DE application is not confined to the engineering domain. Instead, it extends across the entire lifecycle of a program, starting from requirements definition through to closed-loop sustainment. This comprehensive applicability reinforces the importance of the Army's swift and strategic adoption of DE to ensure its long-term relevance and effectiveness.



The study team discovered that there are hundreds of current and relevant DE studies, presentations, reports, and many solid recommendations. The study team also learned that there is no standard definition adopted across the community of interest. DE means different things to different people, especially based on what part of the organization or the life cycle they were working. However, the study team did find consistency and convergence on best practices, and these motivated the study's recommendations. The study team notes that DE is effectively just the next iteration or evolution of systems engineering. DE is not something new. Industry has been investing DE for decades and are now reaping those rewards. Additionally, the study team

repeatedly heard that DE is not a panacea, and it was key to apply it where it makes sense first. Another common theme the study team recognized is the use of a business case approach. It is important to prioritize where to make implementation decisions, understand the costs, and invest where appropriate based on return on investment. The Army has been enthusiastic about DE in many areas and there are pockets of success and failure across the Army in DE. However, while many lessons are being taught, they are not being learned, promulgated or shared consistently across the enterprise. It is crucial that the Army take a more systematic approach to capturing and sharing these lessons so they can be leveraged by others who are embarking on their own digital transformation journeys. DE is an evolution of systems engineering, and it is essential that the Army continue to invest in developing its capabilities while also learning from past experiences. By doing this, the Army will be better positioned to meet the challenges of the future and maintain its competitive edge.



The study team felt it was important to emphasize that DE is not a silver bullet. It is not a cure-all or a catch-all. This is a common theme the study team heard across all the interviews conducted. Adopting DE does not obviate the need for rigorous engineering or good requirements. These are prerequisites. As DE has the potential to revolutionize how the Army does business and runs its operations, it will solve some significant existing problems for the Army. However, it will also introduce and create new problems. This is analogous to the Army's adoption of major game changers such as network centricity, cyber security, and AI. These capabilities solved many problems and introduced many efficiencies but created a whole new host of challenges and vulnerabilities because it changed the way the Army does business and generated, in some instances, new supporting industries. The Army should be aware of this and plan accordingly. Successful adoption of DE will invariably move some of the costs to the left,

especially as the Army starts to pay down its technical debt, catch up, and develop and acquire skills that are needed. Because of this, the Army needs to plan for those initial investments and the timing of those investments before it can start to measure returns on those investments.

The study team learned some consistent lessons from industry with respect to digital transformation. Many digital transformation projects do fail, not limited to DE.

Transformational efforts tend to fail for a number of common reasons. One of the top reasons is a lack of organizational planning, execution, and measurement cycles not being in place to determine long-term stability. For example, when leaders who were championing a cause transitioned out, efforts could fall apart. Being too controlling from the top down with governance and discouraging learning through experimentation was also another key contributor to the failure of digital projects. Under-resourcing the training and up-skilling of staff, infrastructure and tools was another death knell when it came to digital transformation projects. Upskilling of staff means adding to existing staff skill set. It is expanding their capabilities to maintain relevance. The last lesson learned was that inadequate cross-domain and program integration often contributes to failure. For example, “cylinders of excellence” that are not sharing what they were learning or applying. As the Army embarks on its DE journey, it should consider these things in its planning.

Not every program may benefit from implementing DE. The following criteria may be useful to determine whether a DoD Acquisition program is a suitable candidate for implementing DE:

1. **Program complexity:** The more complex the system, the more benefit DE can pr e. Complex systems often involve a high degree of interdependencies among components, and DE can help in visualizing and managing these interdependencies.

2. **Program Lifecycle Stage:** DE is most beneficial when implemented from the start of a program, allowing for efficient and accurate design, development, and testing processes. While it can be beneficial in later stages as well, the cost and effort for implementing it retrospectively could be high.

3. **Integration and Interoperability Requirements:** When a system needs to work in conjunction with other systems, DE can help in ensuring compatibility and interoperability. It also helps in managing interfaces and interactions among various system elements.

4. **Program duration:** For long-term projects, DE could provide substantial benefits in terms of managing changes, maintaining system understanding, and optimizing system performance over time.

5. **Funding and Resources:** Implementing DE requires a significant investment in software, hardware, and human resources. The budget and resource availability for the program should be considered.

6. **Availability of expertise:** Implementing DE requires expertise not only in the engineering domain but also in managing digital models and simulations. The program should have access to such expertise.

7. **Regulatory and Security Concerns:** If the program involves working with sensitive information, DE can provide better control and traceability. However, it is also essential to ensure that the digital tools and methods used are secure and comply with all relevant regulations.

8. **Iterative Process:** DE is especially beneficial for programs where the design is expected to evolve over time with iterative refinement based on testing and feedback.

In addition to these criteria, the DoD's own DE Strategy[2] outlines five strategic goals that could be used to evaluate the suitability of a program for DE:

1. **Formalize** the development, integration, and use of models to inform enterprise and program decision making.

2. Provide a **technically managed** DE environment as an enduring, authoritative source of truth.

3. **Incorporate** technological **innovation** to improve engineering practice.

4. Establish a supporting **infrastructure** and **environments** to perform activities, collaborate, and communicate across stakeholders.

5. **Transform the culture and workforce** to adopt and support DE across the lifecycle.

The study team found several other useful resources for understanding why digital transformations fail:[3]

- Many digital transformation projects fail due to improper adoption, inadequate modeling, insufficient resources, and lack of skill.

- Failure to understand digital transformation: many businesses do not have a clear understanding of digital transformation and its benefits, leading to ineffective strategies

[2] https://ac.cto.mil/wp-content/uploads/2019/06/2018-Digital-Engineering-Strategy_Approved_PrintVersion.pdf

[3] https://pandio.com/top-5-reasons-digital-transformation-efforts-fail/ ; https://www.forbes.com/sites/forbestechcouncil/2021/06/15/13-industry-experts-share-reasons-companies-fail-at-digital-transformation/?sh=1fb334937a3f ; https://www.everestgrp.com/2019-08-why-digital-transformations-fail-3-exhausting-reasons-blog-51164.html

that do not focus on core concepts like scalability, quality, interoperability, flexibility, and cultural transformation.

- Disagreement among leadership: digital transformation can fail if top managers do not share the same vision or lack technological insight. Communicating opportunities and presenting engaging stories can help align goals.

- Lack of DE talent and engineering: employees are critical for a successful digital transformation, but skill gaps and resistance to change can undermine strategies. Train employees and address skill gaps.

- Resistance to change: resistance to change can undermine strategies, build an integrated team-oriented user-centric culture.

- Failure to deliver to user expectations: users expect seamless interactions across multiple channels, but if an organization fails to provide these experiences, they risk losing their users. Establishing multiple digital touchpoints is essential for effective user engagement.

- Poor data analytics capabilities: insufficient data analytics capabilities can result in working with inaccurate or incomplete data, limiting the effectiveness of digital transformation efforts. Building a robust data pipeline is necessary for collecting, storing, and analyzing data to enhance business strategies.

- Inadequate data: the distribution of data across various devices and systems makes it difficult for companies to capitalize on their data growth and deliver new solutions.

- Inadequate DE tools and training: lack of purpose-built systems for onboarding and implementation projects results in reduced transparency and accountability.

- Inadequate compute for DE: layering new technologies onto flawed processes and resistant teams often leads to disappointment.

- Inadequate system requirements: without clear goals and benchmarks for the end product and the user's needs, digital transformation projects are more likely to fail.

- Failure to coordinate across teams: failure often occurs when organizations neglect to synchronize and align goals across the organization.

- Mistaking digitization for digitalization: focusing on digitizing products or processes rather than leveraging the opportunities they provide leads to failure.

- Using an outdated tech stack: a modern tech stack that unifies teams and provides necessary tools is essential for digital transformation success.

- Fear of temporary failure: resistance to initial failures can hinder the progress of digital transformation projects.

- Overestimating benefits and underestimating costs: inaccurate or inadequate information about the benefits and costs of digital transformation projects can lead to failure.

- Lack of up-front commitment: failing to deeply commit to the changes required for a digital transformation, which leads to resistance and project abandonment.

- Failing to take an iterative sprint approach: using a traditional waterfall planning process with a long-term, inflexible plan, which often leads to fatigue and failure.

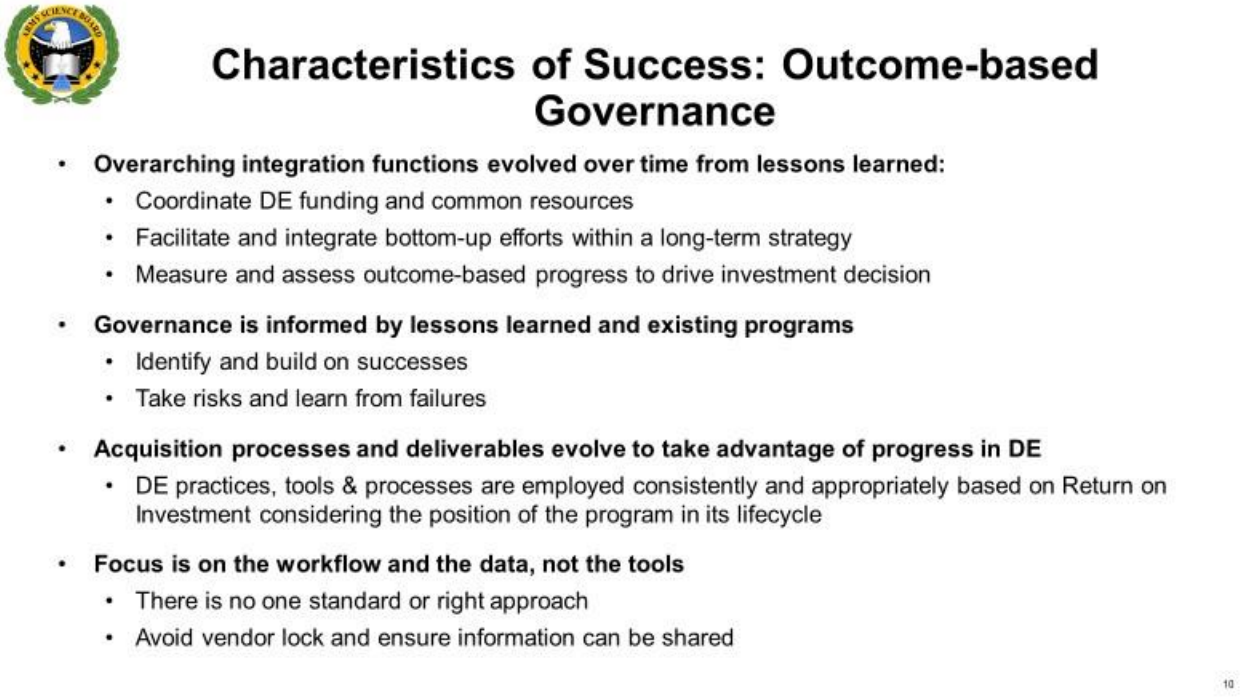
- Taking a technology-first approach: starting with costly legacy replacement activities, which consume resources and distract from delivering transformation benefits.

Finally, the study team identified general practices to avoid such failures:

- Building a collective vision, ensuring stakeholders understand the project's necessity, and fostering personal ownership of the transformation's success.

- Breaking the project into short-term, goal-oriented sprints, and using an iterative, agile approach, allowing for flexibility and evolution based on learnings.

- Understanding required business changes first, implementing technologies that quickly deliver value, and using an iterative approach for subsequent value-adding projects.

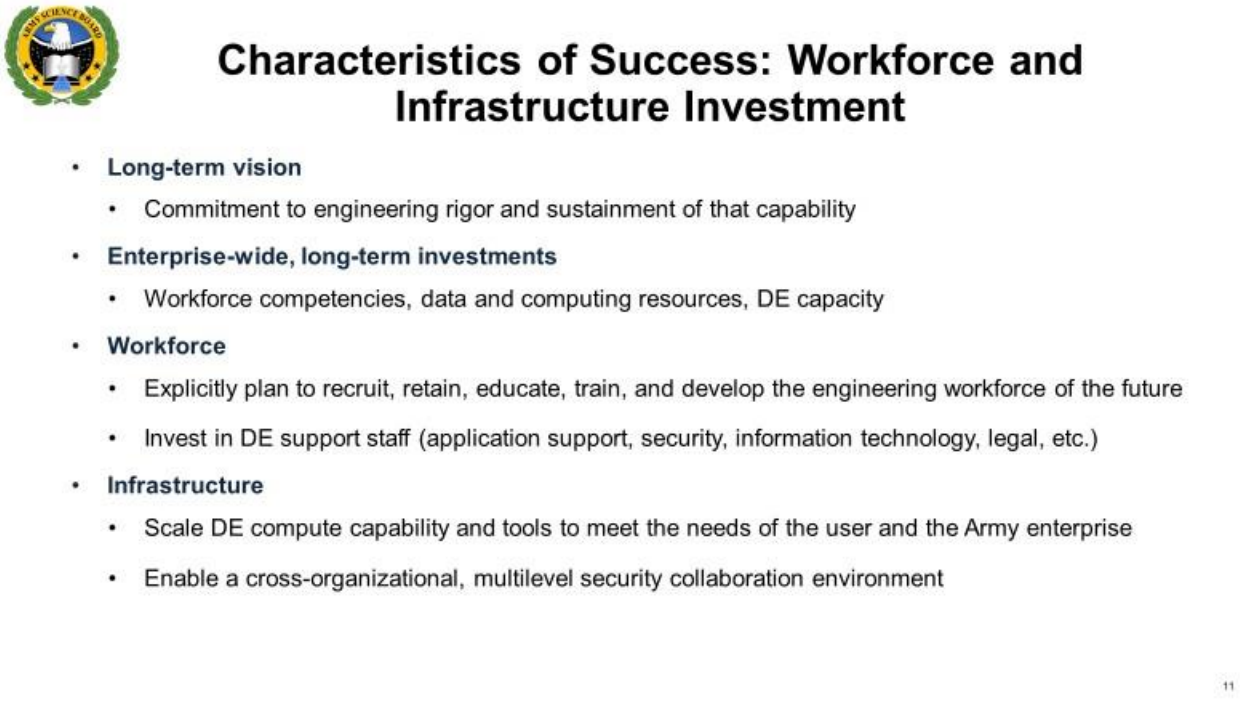


The study team did capture some characteristics of programs and initiatives that were quite successful. Where DE has been successfully implemented, there was an emphasis on outcome-based governance versus governance for governance's sake. In successful adoptions of DE, there was often an overarching integration function that evolved from lessons learned over time. That integration function would coordinate funding and resources across the organization. That integration function would facilitate and integrate bottom-up efforts across the organization and all the experimentation activities against a long-term strategy in support of desired outcomes. And finally, it would measure and assess outcome-based progress to drive investment decisions. For example, it could be how many DE artifacts are being used versus how many are being generated.

The second characteristic is that the governance was actively informed by lessons learned and existing programs. A key lesson is to look for those successes and build on those successes. It is okay to take risks, but what is key is to learn from that risk-taking: learn from failures and incorporate those lessons learned into overarching governance. Acquisition processes and deliverables should evolve over time to take advantage of progress in DE. There is some flexibility that is required here and some risk-taking.

Practices, tools, and processes for DE should be consistently employed based on a return-on-investment assessment; considering where the program is in its lifecycle. Successful organizations that implemented DE did not try to force a one-size-fits-all across all their programs or try to introduce it in programs that were at the tail end of the lifecycle.

Finally, the focus is on the workflow and enabling data sharing, not on selecting tools that might create vendor lock. There is no one standard or right approach, and there was a huge emphasis on avoiding vendor lock to make sure that information could consistently be shared across the stakeholders. Instead, a flexible and adaptive mindset is necessary to navigate the complexities of digital transformation. Data policy and architecture ensure that the right level of information can be shared consistently and appropriately and allow information to be used in different and evolving tools.



Success in workforce and infrastructure investment is not an accident. It requires a long-term vision, commitment to engineering rigor, and sustainment of that capability across the entire organization. The study team found that it was not a matter of buying DE tools and throwing them over the fence, but of having a long-term plan. This long-term plan induces enterprise long-term investments, and that means building up workforce competencies, ensuring appropriate data management and interaction plans, and infrastructure in order to build out DE capacity. Investing in the workforce was seen as critical, and there was an explicit and targeted plan to recruit staff who had DE skills and to retain that staff by making sure they had meaningful work in DE. It was also critical to enable, educate, train, and mentor existing staff within the engineering workforce and other parts of the workforce to continue to develop skills and be able to leverage, recognize, and value DE. There was also a strong investment made in DE support staff – the people key to supporting DE. These include the information technology teams, the security teams, legal, contracts, and many more. The fourth area was infrastructure, and that was about being able to scale the computing capacity of the organization to manage the amount of data and the tools, and that scaling was required for two perspectives. The first is for the individual user and spans to the enterprise level, and then finally, enabling cross-organizational

multi-level security collaboration environments. One of the big challenges many of the interviewees discussed was the challenge of sharing data across programs or organizations while protecting intellectual property. Enabling a collaborative work environment that addresses security and intellectual property concerns was important across organizations to harness the value and impact of DE.

Characteristics of Success: Organizational Learning

- **Use managed DE experiments to drive change**
  - Identify DE experiments for each phase of the lifecycle and across programs
  - Incorporate lessons learned to inform future strategies
  - Integrate lessons across the program lifecycle and business units (e.g., lessons from logistics feed back into production, requirements, etc.)
- **Leverage industry's decades of experience and investment in DE**
  - DE is now a standard way of doing business; it is not a unique competitive advantage
  - Industry is already incentivized; the need is for government to remove disincentives
- **Apply lessons learned, leverage, develop, and maintain the DE body of knowledge**
  - Implement recommendations from significant investments and bodies of knowledge in DE by the Services, FFRDCs, University Affiliated Research Centers (UARCs), industry, associations, academia, etc.
  - Make knowledge accessible

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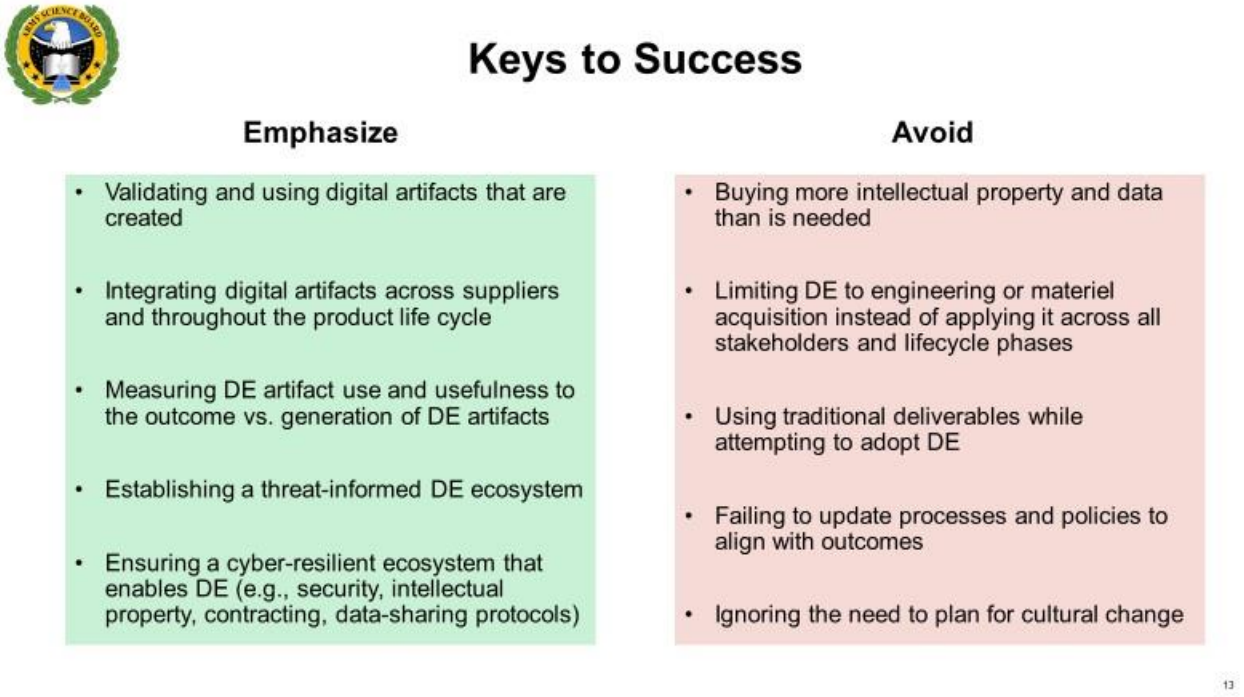
Organizational learning is a critical characteristic of success when it comes to digital transformation. To achieve this, successful adopters of DE identified experiments within phases of the life cycle across different programs to build out their competency. They incorporated those lessons learned to inform next steps and future strategies, and they integrated those lessons across the programs as well as within and across the various business units. For example, things that were learned in logistics would feed back into production or things that were learned in operations would feed back into requirements. Learning was a big part of this. Industry has decades of experience in DE and has been investing in DE. DE is no longer seen as a competitive advantage but as a business necessity. It is the standard way of doing business and they are moving out fast.

Industry is already incentivized. There is no reason to focus on incentivizing them. It is about encouraging the government to remove the disincentives for industry's use of DE. Examples include requiring DE processes but then insisting on delivery of products in traditional formats. That is a disincentive.

Applying lessons learned and developing a DE body of knowledge was the third main characteristics under learning. It was critical that information be shared. As investments are made, as things are being learned there is a DE body of knowledge that works across the industry

to share lessons learned but also within organizations to maintain some of their intellectual property. Making that knowledge accessible and usable is key to success. Because so much has already been done to mature DE, now is the time to implement recommendations from the significant investments in DE by the Services, Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), industry, associations, academia, and others.



The team learned that there are certain behaviors that can help ensure success. These included validating and using digital artifacts rather than creating shelfware and integrating them across suppliers and throughout the product life cycle. The more DE products are used, the more valuable they become. Other positive behaviors entailed measuring DE artifact use and usefulness to the outcome. If a DE artifact is not useful or being used, stop spending money on it and go to what you need versus just tracking how many documents or artifacts you are creating. Ultimately, creating a threat-informed DE ecosystem requires examining upcoming challenges while also safeguarding existing Army assets. This underscores the importance of fostering a cyber-resilient ecosystem. Such an ecosystem not only supports DE from a security standpoint but also ensures the protection of intellectual property, streamlines contracting, and facilitates data sharing across various security tiers.

The study team observed the Army buying more IP and data than is actually needed. This was a common complaint from industry, that the Army wants to buy all the data and that is neither practical nor affordable. Limiting DE to just engineering as opposed to applying it across the entire life cycle and across all the stakeholders was contraindicated. A common example is

requiring DE development in the front part of the life cycle only to maintain requirements for two dimensional drawings for logistics and sustainment.

The Army should look at DE with an end-to-end perspective. Another DE disincentive is failing to update processes and policies to align with outcomes. The Army will need to look at its policies and processes and determine which of these needed to be updated as it learns more about how and where to apply DE.

The final behavior to avoid is not planning accordingly for change management. Plan for culture change because successful adoption of DE is a foundational overhaul of how the Army does business and makes decisions. Investments and deliberate planning to manage those changes are going to be needed.

FINDINGS

Finding

Experimentation at scale is critical to capturing where DE works and where challenges must be overcome

- No need to wait on further study - Army has access to what is necessary to accelerate adoption of DE
- Army will be challenged to implement enterprise-wide DE without an integration office; however, the form and focus of this office should be derived from lessons learned (experimentation & ongoing pathfinders)

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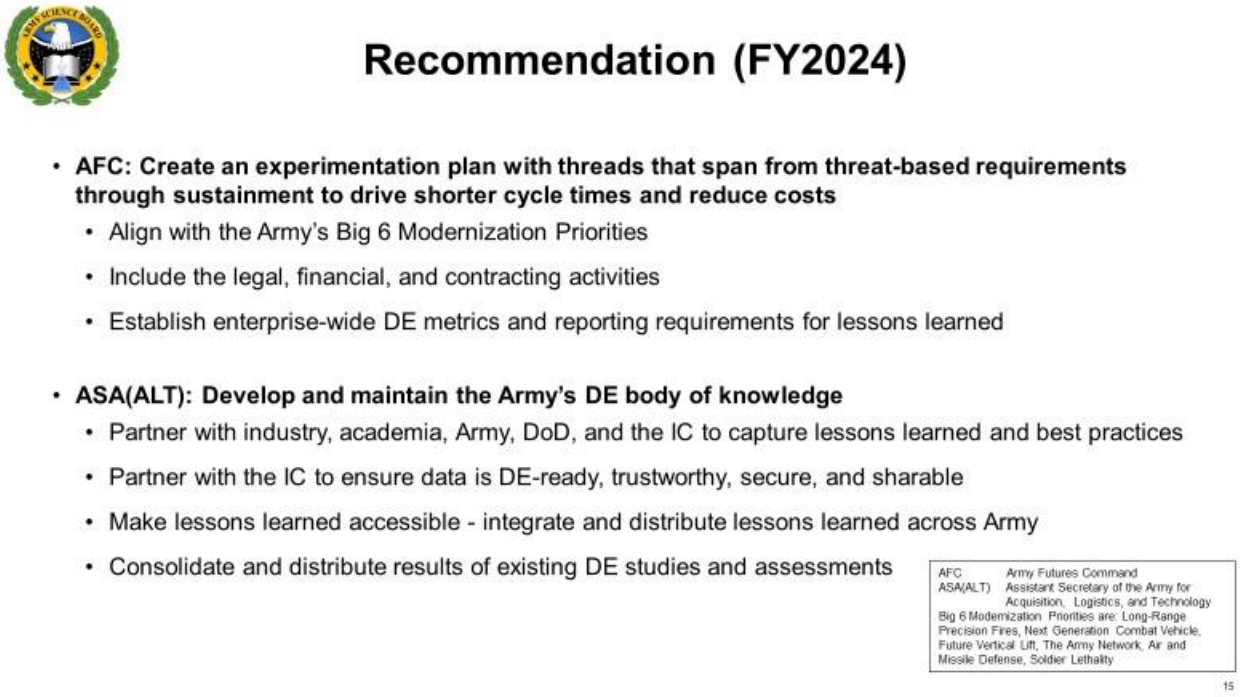
The main finding of the study team is that experimentation at scale is going to be crucial to where DE is going to work and what challenges need to be addressed across the life cycle for the Army. This study team has determined and recommends that there is no need to wait for further study. This topic has been studied quite significantly. The Army has access to what is necessary to accelerate the adoption of DE today. It may not know that it has access to it, but it does.

The study team conducted several interviews, reviewed reports and presentations, and concluded that, while DE meant different things to different people, there was consistency and convergence on recommendations in the areas of governance, leadership, workforce, infrastructure, security, data, and intellectual property. The Army has pockets of success and failure, but lessons are not being learned, promulgated, and applied across the enterprise.

The Army will be challenged to implement enterprise-wide DE without having an integration office established. However, the study team does not believe that the office or organization should be established until the Army learns some lessons through experimentation and with pathfinders that exist today across the Army. The study team believes this approach fits the culture of the Army and enables the Army to effectively leverage lessons learned from industry and its own activity to set the conditions for a successful and needed integration organization. In the meantime, DE adoption should be championed by both the SA and CSA and the eventual integration office should jointly report to both.

RECOMMENDATIONS



RECOMMENDATION 1.

The study team's near-term recommendations to accelerate DE adoption in FY24 are aligned to organizations in priority order.

The study team believes that the Army Futures Command (AFC) has a critical role in ensuring that the Army remains at the forefront of data-driven decision making. To achieve this goal, the team recommends that AFC should create an experimentation plan with threads that span from threat-based requirements through sustainment to drive shorter cycle times and reduce costs. The experimentation plan should consider DE from a system of system perspective.

The study team does not suggest that a single experiment needs to cover the entire lifecycle. Rather, the study team suggests initiating several experiments at various stages of the lifecycle and across diverse program types. These programs may vary in size and characteristics, providing opportunities to develop and learn valuable lessons.

To ensure relevance, the study team recommends that AFC should align with the Army's 6 modernization priorities: long range precision fires, next generation combat vehicles, future vertical lift, network, air and missile defense, and Soldier lethality. By focusing on these critical areas, AFC can ensure that it is meeting the needs of the Army both now and in the future.

Moreover, the study team believes it is imperative to involve legal, contracting, and financial teams from the onset. These parties, often neglected until the final stages, are instrumental to acquisition success. Involvement from day one allows for their contribution to brainstorming and creation of experiments.

The study team believes that establishment of enterprise-wide metrics and reporting requirements is another critical factor. While it is unnecessary for these metrics to be exhaustive, some overarching indicators can provide valuable insights into the progress over time and facilitate integration across the enterprise. Detailed investigations into this area would be beneficial.

The Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) has a critical role to play in ensuring that the Army remains at the forefront of data-driven decision making. The study team recommends that ASA(ALT) should be directed towards the development and maintenance of a DE body of knowledge for the Army. The term 'DE body of knowledge' has been deliberately chosen, despite its potential unfamiliarity within the Army context, due to its acceptance and understanding within the DE community. The study team has four recommendations.

Firstly, ASA(ALT) should work closely with industry partners to ensure that they are fully versed in the latest DE techniques and best practices. This will help to drive innovation and ensure that the Army is always using innovative technology to make data-driven decisions. Additionally, ASA(ALT) must partner with the IC to capture lessons learned and best practices that incorporate current and emerging threats.

Secondly, ASA(ALT) should work closely with the IC to ensure that all data is DE-ready, trustworthy, secure, and sharable. This will help to build confidence in the Army's decision-making process and ensure that all stakeholders are working from the same information.

Thirdly, ASA(ALT) should make lessons learned accessible by integrating and distributing them across the Army. This will help to drive a culture of continuous improvement within the organization and ensure that everyone is learning from their experiences.

Finally, ASA(ALT) should consolidate and distribute the results of existing DE studies and assessments. By doing so, they can identify areas where further investment is needed and ensure that the Army is using its resources in the most effective way possible.

Recommendation (FY2024) - Concluded

- **G2: Develop a plan to integrate intelligence data into the DE ecosystem in a cyber-resilient way**
  - Partner with the Army Counterintelligence Command and ARCYBER to plan for securing the integrity of models and data and to support an environment for multi-level collaboration
  - Synchronize current and emerging threats across acquisition and the IC from concept through sustainment

ARCYBER Army Cyber Command

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The study team recommends that, working closely with Army Counterintelligence Command (ARCIC) and Army Cyber Command (ARCYBER), G2 should also focus on planning for securing the integrity of models and data, as well as supporting an environment that fosters multi-level collaboration. This will require a coordinated effort across multiple stakeholders to ensure that intelligence data is effectively integrated into the DE ecosystem in a way that is both secure and resilient against cyber threats.

The IC has two roles. One of those is to assist the Army to recognize that as it implements DE, the Army creates new vulnerabilities. The G2 should work with ARCYBER to make sure that the Army understands those vulnerabilities. The second role is for G2 to ensure that the Army understands how to integrate threats into models so that the DE models that Army develops and tests with are relevant.

DE requires movement of data across multi-level security planes, and this is going to be a challenge. The study team found examples where DE implementation was inhibited by multilevel security issues. It is critical that these are addressed to enable the appropriate data exchanges and secure environments essential to successful DE implementation.

In FY2025-FY2028, the study team recommends that G8 put in place funding for the experimentation plan proposed by AFC, and fund investments in the DE workforce and the infrastructure plans.

The study team recommends that the AFC should implement DE experimentation in partnership with the Army's industrial base. That means hosting events like digital twin integration experiments to identify where the gaps are. The study team anticipates some of those breaks to be in the areas of common standards, intellectual property sharing and protection, data integrity, model validation, and which tools can and should be used. The study team recommends that AFC partner with industry to identify which standards are appropriate to enable successful adoption of DE across the enterprise. AFC should identify what a unified ecosystem would look like. That includes the industrial base, taking lessons learned and findings from pathfinders from the bottom-up, and feeding those lessons learned into governance and an overarching strategy top-down. Leveraging digital twins will enable faster and more thorough testing at less cost than traditional methods. Areas AFC could explore include test scenarios, hardware, software, and end-to-end capabilities. Potential venues to test those out and attract industry participation include Project Convergence and Radio Rodeo.

Recommendation (FY2024-FY2028) - Continued

- **ASA(ALT): Leverage and apply the DE body of knowledge**
  - Use lessons learned to delineate functions for an enterprise-wide integration office and inform governance
  - Identify promising candidates and resources required for early/accelerated DE adoption

- **G2: Integrate intelligence data and cyber-resilience into the DE experimentation plan**
  - Partner with AFC, Counterintelligence Command, ARCYBER, and the broader IC to secure DE and define threat-informed scenarios

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In FY2025-2028, the study team also recommends that ASA(ALT) leverage and continue to apply the DE body of knowledge. ASA(ALT) should continue to capture lessons learned to determine what is required from a future enterprise-wide integration office or organization. Additionally, these will inform governance and help the enterprise-wide integration office work across the Army's programs and initiatives to identify good DE experimentation candidates. ASA(ALT) should identify those programs and resource them. The study team recommends that the G2 integrate the intelligence and data and cyber resilience efforts that they develop in FY2024 into the DE experimentation plan. That means working very closely with AFC, Army Cyber Command (ARCYBER), and the Army Counterintelligence Command (ARCIC), to secure DE, define threat informed scenarios, and determine how to protect the data, models, and the ecosystem.

Recommendation (FY2024-FY2028) - Concluded

- **M&RA & G1: Produce DE Workforce plan based on lessons learned from DE experiments**
  - Establish a DE skill identifier
  - Partner with key stakeholders to develop targeted continuing education programs and incentives

- **G4: Oversee the development and implementation of DE practices and procedures with industry for logistics and sustainment**
  - Perform workflow analyses to update policy, processes, practices, and inform DE governance
  - Incorporate lessons learned into the Army's DE body of knowledge

M&RA Manpower & Reserve Affairs

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Finally, the study team recommends that Manpower & Reserve Affairs (M&RA) and the G1 develop a DE workforce plan based on lessons learned from the DE experiments. That includes establishing a DE skill identifier and the associated follow-on activities to address DE competencies for hiring and planning. M&RA should partner with key stakeholders to develop targeted continuing education and incentives for attracting and retaining the staff with the right DE skills that the Army needs.

The study team recommends that the G4 oversee the development and implementation of DE practices and procedures partnering with industry for logistics and sustainment. That means conducting workflow analyses to update policies, processes, and practices and to provide those recommendations back to DE governance. The study team recommends incorporating the lessons learned from this process into an ASA(ALT) managed DE body of knowledge.

APPENDIX A – TERMS OF REFERENCE

SECRETARY OF THE ARMY
WASHINGTON

06 JUL 2023

MEMORANDUM FOR

ASSISTANT SECRETARY OF THE ARMY (ACQUISITION, LOGISTICS, AND TECHNOLOGY), 103 ARMY PENTAGON, ROOM 2E532, WASHINGTON, DC 20310–0103
CHAIRMAN, ARMY SCIENCE BOARD, 2530 CRYSTAL DRIVE, SUITE 7098, ARLINGTON, VA 22202

SUBJECT: Terms of Reference for Army Science Board Study "An Independent Assessment of the Army Implementation of Digital Engineering"

1. I request the Army Science Board (ASB) conduct a study titled "An Independent Assessment of the Army Implementation of Digital Engineering." The purpose of the study is to identify progress, challenges, and opportunities to enable successful adoption of digital engineering by the Army.

2. Digital engineering (DE) advances traditional systems engineering practices to take advantage of computational technology, modeling, analytics, and data sciences. In February 2022, the Under Secretary of Defense for Research and Engineering published the "Systems Engineering Guidebook" and "Engineering of Defense Systems Guidebook." These documents were issued IAW the new Department of Defense (DoD) Instruction 5000.88 "Engineering of Defense Systems," instructing all programs of record to implement DE. An assessment of the Army's implementation of DE would identify strengths and weaknesses and help inform the Army Futures Command and Assistant Secretary of the Army (Acquisition, Logistics, and Technology) of any shortfalls needing attention to comply with the new guidance.

3. The study team's tasks shall include, but not be limited to, the following:

a. Identify and understand current impediments to Army DE efforts and plans.

b. Investigate current DE benchmarks—practices, knowledge, and capabilities—by DoD, other Services, government agencies, non-defense industry, and academia that the Army could leverage.

c. From the data gathered, develop near-term enhancements for Army DE environments with measurable processes for evaluating effectiveness. These should inform Army strategy and identify innovative ways for the Army to incrementally implement digital engineering.

4. The Under Secretary of the Army will sponsor this effort. The Deputy Assistant

SUBJECT: Terms of Reference for Army Science Board Study "An Independent Assessment of the Army Implementation of Digital Engineering"

Secretary of the Army (Data, Engineering, and Software), and the Army Futures Command Deputy Commanding General for Acquisition and Systems/Chief Innovation Officer will support the effort and assist the study team. Support will include providing a government representative, grade O-5 (or civilian equivalent), to act as an Alternate Designated Federal Officer for the study and providing access to classified information and other resources as needed. The sponsors will conduct synchronization meetings with the study team every 60 days.

5. Provide a briefing with findings and recommendations by 31 August 2023 to the Under Secretary of the Army. The study will operate in accordance with the Federal Advisory Committee Act and DoD Directive 5105.4 (DoD Federal Advisory Committee Management Program). It is not anticipated that this study will need to go into any particular matters regarding the meaning of the United States Code, nor will it cause any member of the study team to be placed in the position of acting as a procurement official that may constitute a conflict of interest.

Christine E. Wormuth

CF:
Chief of Staff of the Army
Under Secretary of the Army
Vice Chief of Staff of the Army
Deputy Chief of Staff, G-2
Deputy Chief of Staff, G-3/5/7
Commander
U.S. Army Materiel Command
U.S. Army Futures Command

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APPENDIX B – STUDY TEAM MEMBERS AND VISITATIONS

Team Members and Visits

Team

Quick Reaction Team

- **Alex Brofos (Study Chair)**
- **Melissa Flagg (Vice Chair)**
- **Emaan Osman (Vice Chair)**
- **Jean Dasch**
- **Jeffrey Reed**
- **Richard Wittstruck (Government Advisor)**
- **David Gorsich (Government Advisor)**
- **Michael Gully (Government Advisor)**
- **Dean Bucher**
- **Mike Molino**
- **Bill Berklich (Government Advisor)**
- **Vinson Bullard (Study Manager)**
- **Leonard Braverman (Senior Advisor)**

- William Neal (Chair)
- Charlotte Farmer (Vice Chair)
- Venkat Mummalaneni (Vice Chair)
- Tom Mahnken
- Mike Macedonia
- Bill Crowder
- Amber Walker
- Grace Bochenek
- Jeremy Lanman*
- Jim Schirmer*
- Paul Hoppe*
- John Farr

Briefings

Industry

- Siemens
- Northrop Grumman
- Ford
- Logistics Management Institute
- Prewitt Ridge
- Istari
- Lockheed
- Raytheon

Other

- Aerospace
- International Council on Systems Engineering
- MITRE

US Government

- **Army**: Optionally Manned Fighting Vehicle/Ground Vehicle Systems Center; Aviation and Missile Center; Armaments Center; Deputy Assistant Secretary for Data, Engineering, and Software; Chief Data Officer
- **Department of Defense**: Undersecretary of Defense for Research and Engineering; Assistant Secretary of the Air Force (Acquisition, Technology, and Logistics); Deputy Assistant Secretary of the Navy for Research Development Test and Evaluation; United States Space Force
- **Department of Energy**: National Nuclear Security Agency

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APPENDIX C – LINES OF INQUIRY

14 Lines of Inquiry were Posed to a Sampling of DoD and non-DoD Organizations

1. How is Digital Engineering being used by your Organization?
2. What are the prerequisite conditions, programs, and phases for implementing Digital Engineering from your point of view?
3. What are the processes and phases where Digital Engineering is especially beneficial?
4. What metrics can be used to assess Digital Engineering effectiveness?
5. What are valuable Digital Engineering models and processes suitable for reuse?
6. How can the Army benefit from experience with Digital Engineering?

7. What opportunities exist for the Army to benefit from Digital Engineering?
8. What are the major benefits of Digital Engineering for the Army?
9. What are recommended courses of action for the Army to promote the use of Digital Engineering for its transformational benefit?

10. What governance structures are recommended for standardizing and promoting Digital Engineering best practices?
11. What standards, tools, and frameworks for implementing Digital Engineering are recommended?
12. How should Digital Engineering models be federated and integrated?
13. How should Digital Engineering staff be acquired, developed and sustained?
14. What incentives should the Army employ to promote industrial application of Digital Engineering?

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APPENDIX D – RACI analysis of Recommendations

Responsible, Accountable, Consulted, and Informed (RACI) Analysis of Recommendations

Task-Role	SecArmy	CSA	AFC	IMCOM	TRADOC	ARCYBER	ACC	ASA(ALT)	M&RA	FM&C	OGC	DCS G-8	DCS G-4	DCS G-2	IC	Industry
FY 24																
Develop Experiment Visison/Goal	I	A	R	I	C	C	I	C	C	I	I	C	C	C	C	C
Develop Experimentation Plan Assgin Roles	I	A	R	I	C	C	I	C	C	C	I	C	C	C	C	C
Align with Big 6	I	A	R	I	C	C	I	C	C	C	I	C	C	C	C	C
Establish Standards/Metrics	C	A	R	I	I	C	I	C	I	C	C	C	C	C	C	C
Consolidate results	A	C	I	C	C	C	C	R	C	C	C	C	C	C	C	C
Make lessons learned accessible	A	C	C	C	C	C	I	R	I	I	I	C	C	C	C	C
Develop Industry Agreements	I	I	A	I	I	I	R	C	I	C	C	C	C	C	C	C
Integrate intel into DE experiment	I	I	A	I	I	C	I	C	I	I	I	C	C	R	C	C
Ensure cyber resilience in DE experiment	I	C	A	I	I	C	I	C	I	I	I	C	C	R	C	C
Insure Acq informed by threat	I	C	A	I	C	C	I	C	I	I	I	C	C	R	C	C
FY 25-28																
Fund experiments	C	A	C	I	I	I	I	C	C	C	I	R	C	C	C	I
Fund infrastructure and workforce	C	A	C	C	C	I	I	C	C	C	I	R	C	C	C	I
Drive enterprise wide adoption of DE	C	C	R	I	C	C	I	A	C	C	I	C	C	C	C	C
Identify candidates and resources for DE adoption	I	C	R	I	C	C	I	A	C	C	I	C	C	C	C	C
Impliment DE integration experiments	I	C	R	C	C	C	C	A	I	C	I	C	C	C	C	C
Host digital twin integration experiments	I	C	R	I	I	I	I	A	I	C	C	C	C	C	C	C
Work with industry for standards	I	C	R	I	I	I	I	A	C	I	I	C	C	C	C	C
Explore unified ecosystem	A	C	R	I	I	I	I	C	C	I	I	C	C	C	C	C
Leverage digital-twins	I	C	R	C	C	C	C	A	I	C	I	C	C	C	C	C
Integrate intel into DE experiment	I	C	A	I	I	C	I	C	I	I	I	C	C	R	C	C
Produce DE workforce plan	C	C	A	I	C	C	I	C	R	I	I	C	C	C	C	I
DE Skill Identifier	I	C	A	I	C	I	I	C	R	I	I	C	C	C	C	I
Continuing Education Program	C	C	C	I	R	I	I	C	A	I	I	C	C	C	C	I
Logistics and Sustainment	I	C	A	C	C	C	I	C	C	C	I	C	R	C	C	C

Enterprise-wide implementation will require direct involvement of the SA/CSA until Integration Office is established

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APPENDIX E – Acronyms

Acronyms Used in this Brief

AFC	Army Futures Command
AI	Artificial Intelligence
ARCYBER	Army Cyber Command
ARSTAF	Army Staff
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
CSA	Chief of Staff of the Army
DASA(DES)	Deputy Assistant Secretary for the Army (Data, Engineering & Software)
DAU	Defense Acquisition University
DE	Digital Engineering
DoD	Department of Defense
FFRDC	Federally Funded Research & Development Center
FY	Fiscal Year
HQ	Headquarters
IC	Intelligence Community
IP	Intellectual Property
M&RA	Manpower & Reserve Affairs
ML	Machine Learning
NNSA	National Nuclear Security Agency
ODASD (SE)	Office of the Deputy Assistant Secretary of Defense (Systems Engineering)
QRT	Quick Reaction Team
RACI	Responsible, Accountable, Consulted, and Informed
SA	Secretary of the Army
SE	Systems Engineering
UARC	University Affiliated Research Center
USA	Undersecretary of the Army

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